DVD: *breathtaking sight and sound, significant challenges*

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Offering almost a tenfold boost in capacity compared with CD-ROM media, DVD-ROM media can easily store an entire digitally encoded and compressed movie or a more complex computer game than the entertainment world has yet conceived. It's precisely the potential of that mammoth capacity that makes DVD a different animal from CD. To effectively integrate DVD into a system, you also have to decode MPEG-2 video and Dolby AC-3 audio. The pristine video quality has Hollywood worried about unauthorized duplication of titles, so you have to design in hefty decryption capabilities and get a license. In a computer-centric design, you must also mix these new-media streams with standard 2- and 3-D graphics. Surprisingly, however, IC vendors are already shipping DVD chip sets, and continuing μP performance gains will enable soft DVD not too far down the road.

Long-awaited DVD technology stands poised and ready to enter our living rooms and our PCs and promises to converge the entertainment and computer environments. Designers simply have to figure out how to decode the compressed video and audio, mix DVD and graphics, handle security and encryption, and do it all cheaply.

Toshiba's $3000 DVD evaluation kit allows designers to evaluate the new technology, and the companion $15,000 reference design and manufacturing kit can jump-start design efforts.

The successor to CD technology, DVD has taken seemingly forever to arrive for those individuals who have followed its development. Bickering camps of consumer-electronic giants almost announced and shipped incompatible DVD-like products several years ago. Fortunately, IBM coerced the two camps

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into developing a unified standard and forgoing a VHS-vs-Betalike battle in the market. Even today, however, DVD proponents can't agree on what DVD stands for—digital video disc, digital versatile disc, or nothing. (See **box**, "DVD basics." For more detailed information on the history and current state of DVD technology, go to the Internet and find the DVD FAQ in the alt.video.dvd newsgroup. The FAQ is also mirrored at several Web sites, including www.videodiscovery.com. Toshiba's Web site also includes an informative DVD section.)

DVD-ROM media stores 4.7 Gbytes of data per side and will find extensive use in both the consumer-entertainment and computer industries. Vendors of consumer players have a clear DVD vision. The technology offers far superior video and audio quality than do VCRs and marginally better video and audio quality than do laser disc players. Compared with laser discs, DVD also offers greater capacity; lower cost; and more "trick" features, such as multiple camera angles and more audio tracks. DVD players arriving at consumer-electronic superstores have prices of $500 to $2000.

@a glance

- DVD provides pristine video and audio quality.
- System and board vendors take responsibility for security flaws.
- Mixing video and graphics may require you to pick a DVD decoder to match your graphics IC.
- In the PC market, host-based decoding software will eliminate the need for DVD ICs within two years.

DVD use in the computer industry will evolve more slowly than it has in the consumer-entertainment industry. You can use DVDs to play movies on a PC, but doing so hardly seems like an everyday application unless your PC is in your living room. The added capacity that DVDs afford will allow educational titles, such as multimedia encyclopedias, to proffer more data and particularly more lengthy and compelling video and audio clips. Without doubt, over time DVD technology will also yield more compelling games that mix video with 3-D graphics.

You can buy DVD add-on kits for PCs today for around $500. The kits from companies such as Creative Labs (Milpitas, CA) include an ATA (AT-bus-attachment)-interface DVD-ROM drive (see **box**, "Evaluating DVD drives") and a PCI-bus board that handles MPEG-2 video and Dolby AC-3 audio decoding. Note that the DVD-ROM drive can read CD-ROMs and can thus simply replace the CD-ROM in a PC. In fact, the drop-

DVD BASICS

A consortium of consumer-electronic and video-content companies created DVD technology and standards. Many of the parties involved focus on the consumer-video industry, but DVD will be equally important to the computer industry. This spring, the companies formed the DVD Forum to shepherd the technology. By early July, the DVD Forum still had no mailing address, Web site, or any other type of public identity. With any luck, it will come forward this year as a central clearinghouse for specs and licensing information. Thus far, the consortium has developed standards for a number of formats and media types.

On CD-like media, DVD-ROMs store 4.7 Gbytes of data per side—typically sufficient for 2 hours of compressed digital video and audio. The DVD-ROM spec also allows "dual-layer recording," which can double the 4.7-Gbyte/side capacity. All DVD players can read the dual-layer media.

DVD-ROM players can also read CD-ROMs and in some cases CD-R (CD-recordable) and CD-RW (CD-rewritable) media. Unlike the CD-ROM industry, the DVD industry plans to use both sides of the medium. Most mainstream players will include only the laser and electronics to read one side. To access the reverse side, the user must flip the disc. Some high-end players may include dual-side support.

Today, consumers can find movies and a few other video titles on DVD-ROM. Movies cost $20 to $30 retail. The movie studios that ship DVD titles typically use each side of the DVD-ROM to store versions of a movie except in the rare case when a movie doesn't fit on one side. Typically, one side contains the version that is edited to fill a standard TV screen. The second side contains the original wide-screen version that must be shown in a letterbox format on a standard TV. In addition, DVD movies typically include multiple audio tracks in different languages.

The DVD standard also allows a publisher to include as many as eight chronologically synchronized video streams that are shot from different camera angles. For example, one company has produced a golf-instruction DVD-ROM that allows the user to change camera angles and view the demonstrations from above, in front of, and behind the golfer. The user can switch angles in real time, maintaining the correct chronological position in the video stream.

The companies behind DVD have also defined DVD-R (DVD-record-once) and DVD-RAM (DVD-erase-and-record-many-times) formats that store 3.95 and 2.58 Gbytes, respectively. DVD-R capacities should move up to 4.7 Gbytes a year or two down the road. All DVD players will read DVD-R media.

DVD-R units aren't yet available and will probably cost almost $20,000 when shipped this year. Prices should drop to approximately $5000 over next year. Blank DVD-R media will cost $30 to $50. DVD-RAM drives will read other types of DVD and CD media, but standard DVD drives will not read DVD-RAM media. DVD-RAM uses optical phase-change technology and primarily targets computing applications, such as backups and archives. DVD-RAM drives will cost less than $1000, and the media will cost $30 to $80.

ping price of DVD-ROM drives ensures that by the end of 1998, the CD-ROM will effectively disappear. High-end systems will include DVD-ROM drives as standard features by the end of this year.

DVD has broad appeal

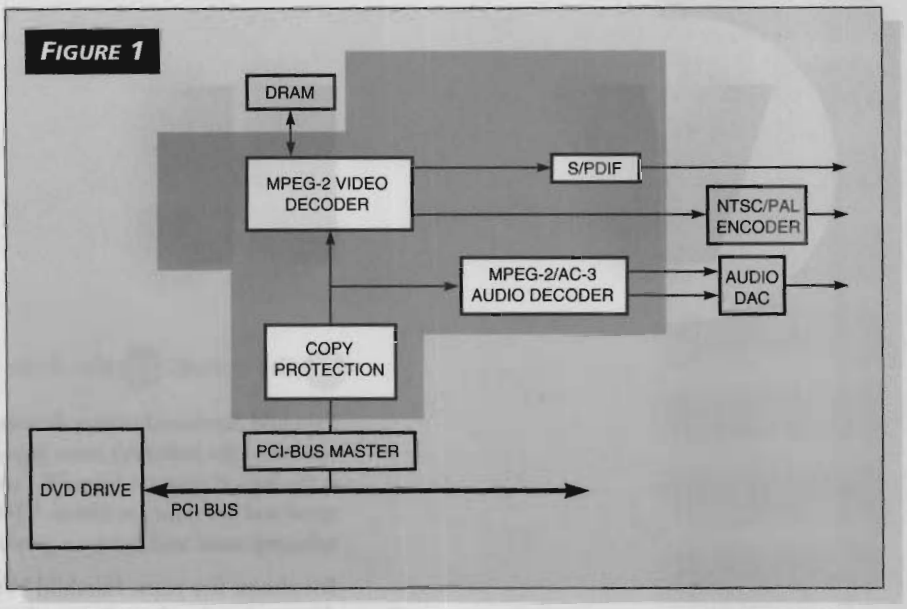
The allure of DVD should have all system designers thinking about how to integrate the technology into their designs. DVD will certainly proliferate quickly in PCs and workstations. Moreover, embedded applications, such as flight or driving simulators, should find use for the technology, and DVD-RAM (DVD erase and record many times) can significantly extend the capacity and capabilities of data-acquisition systems.

Table 1 summarizes the chip sets that are available and that squarely target the DVD market. It's doubtful that you could discern any differences in audio or video quality should you experience a DVD demonstration played via reference designs using these chip sets. All of the offerings produce better video and audio than you are likely accustomed to. Ultimately, you must evaluate the offerings based on the MPEG-2 decoder architecture, security and encryption implementation, audio quality, video/graphics support, level of integration and road map to single-chip DVD, and system costs.

The MPEG-2 decoder block easily qualifies as the most complex part of the overall DVD subsystem, as the C-Cube Ziva architecture shows (Figure 1). You can't differentiate one MPEG-2 decoder from the next just by looking at picture quality. The MPEG-2 encoding that produces a DVD title ultimately limits the output quality achievable in the decoder. You still may want to consider, however, just how the vendors implement the decoder.

For example, Toshiba, SGS-Thomson, and LSI Logic offer hard-wired MPEG-2 decoders that ultimately can handle higher incoming bit rates without fear of ever dropping frames. On the other hand, all the other decoders that are essentially implemented in firmware for DSP or RISC processors should handle any DVD stream with no problem. The firmware approach could conceivably allow vendors to tweak their MPEG-2 decoders to optimize quality or to accommodate changes in the MPEG standard. Such capability proved valuable during the development of the MPEG-2 spec, but

FIGURE 1



The Ziva architecture from C-Cube depicts the key functional blocks required in a DVD player and demonstrates that a single-chip implementation is close at hand.

EVALUATING DVD DRIVES

With all of the issues surrounding DVD, you might think that you face a formidable chore in evaluating DVD drives. Actually, the drives look and work like CD-ROM drives and share a fair amount of technology, including the ATA interface. You can likely buy DVD-ROM drives from your current CD-ROM vendor. Early market leaders include Toshiba and Hitachi.

Only a few differentiating features exist among DVD drives, and Hitachi's products best illustrate these features, because they are the only second-generation drives shipping. The company's GD-2000 is a double-speed drive compared with first-generation drives. It transfers data at around 3 Mbytes/sec, which is the equivalent to a 24x CD-ROM. Going much faster is problematic for the onboard DSP and buffer memory, so you won't see a significant increase in data rate for some time.

The other key lies in the optic subsystem. To read CD-ROM and CD-R media, a DVD drive must adapt to different optical characteristics. Hitachi's drive uses a dual-laser and -lens system, along with a mechanical actuator, so that it can adapt to the media that a user inserts. Make sure you closely evaluate a drive for such features, especially in the short term when DVD technology is relatively new.

Expect DVD-ROM-drive prices to tumble rapidly during the second half of this year. In volume, prices should be less than $200 by year-end. Hitachi is even bullish on the price of DVD-RAM drives and believes that these rewritable units may ultimately replace the floppy drive. Hitachi is the only company shipping such products now, but OEM prices are already less than $500. Moreover, the difference in manufacturing cost between DVD-ROM and DVD-RAM drives could be far less than $100, assuming that manufacturers build the two drives in similar volume.

today the spec is fairly concrete.

Chromatic's Mpact media processor is a special case. When used strictly as a DVD player, an MPact1 IC has no problem handling the various decoding tasks. Chromatic developed Mpact, however, as a multipurpose processor that can handle 2-D graphics, modem, audio, and other functions in a PC. Should your design use an Mpact IC, you have to realize that the processor could stumble on DVD tasks if it were simultaneously executing the modem, 2-D graphics, or other functions. On the other hand, the board vendors currently shipping Mpact1-based DVD boards are dedicating the processor to the DVD task.

Chromatic's architecture also proves to be the most flexible of the bunch. The company licenses functions such as DVD or modems via firmware modules it calls Mediaware. IC-vendor partners Toshiba, SGS-Thomson, and LG Semicon manufacture and sell the Mpact ICs that Chromatic designs. Chromatic claims that its Mediaware approach allows it to tailor the back end of the MPEG-2 decoding process and optimize quality for specific video/graphics-accelerator ICs. For example, Chromatic offers DVD Mediaware with video postprocessing optimizations for ATI, S3, Brooktree (San Diego), and Tseng Labs (Newtown, PA) graphics accelerators.

Copy protecting MPEG-2 streams

Security and encryption provide other examples of features that either work or don't work, yet there's more to consider before you can sell a DVD system. Every vendor of DVD ICs, boards, or systems must get a CSS (content-scrambling system) license before selling its product. Panasonic/Matsushita currently administers CSS licensing, but this licensing will soon fall under the umbrella of the DVD-Forum that's under formation. The CSS process ensures that designs meet security guidelines that have been hammered out with the major Hollywood movie studios. The studios fear that the MPEG-2 digital-video technology might allow hackers to make perfect copies of movies. The CSS process essentially ensures that a decrypted but still compressed MPEG-2 data stream can't be captured.

All of the ICs in **Table 1** have CSS licenses, yet you still must get an additional board- or system-level license to sell a product based on the ICs. Moreover, should you sell a board- or system-level product that a hacker subse-

TABLE 1—REPRESENTATIVE DVD-IC VENDORS

Company and product	DVD features and comments
C-Cube Microsystems, Circle No. 337 Ziva: RISC-microcontroller-based single-chip DVD decoder	MPEG-2 video decoder; AC-3, MPEG, and PCM audio decoders; CSS decryption
Chromatic Research, Circle No 338 Mpact1: multifunction media processor capable of 2-D graphics and video, telephony, modem, and other functions	MPEG-2 video decoder; AC-3 and PCM audio decoders; CSS decryption; AC-3 Digital Dolby simulation on two speakers; audio mixer for auxiliary line inputs
Mpact2: multifunction media processor with hard-wired, 3-D-graphics engine and all of the other capabilities of Mpact1	All Mpact1 DVD features plus enhanced performance that allows simultaneous 3-D graphics and DVD operations
ESS Technology, Circle No. 339 ES 3308: digital audio/video-decoder IC with both a RISC microcontroller and a DSP integrated on one chip	MPEG-2 video decoder; AC-3 audio decoder; CSS decryption; ATA DVD-ROM interface; microcontroller for consumer-player user interface; capable of DVD and set-top box for digital-cable or satellite transmissions
IBM Microelectronics MPEG-CD1: MPEG-2 decoder based on a RISC microcontroller hosts	MPEG-2 decoder IC; CSS decryption and AC-3 audio-decoder function implemented in software for Pentium
LSI Logic, Circle No. 343 L64020: MPEG-2 DVD decoder implemented with hard-wired logic and offered though the CoreWare ASIC program	MPEG-2 video decoder; AC-3, MPEG, and PCM audio decoders; AC-3 Digital Dolby simulation on two speakers; companion CSS-decryption IC planned for third quarter
SGS-Thomson, Circle No. 344 STi3560 Omega: DVD decoder implemented with hard-wired logic	MPEG-2 video decoder; AC-3 and MPEG audio decoders; CSS decryption; PCI and VIP interfaces; also available in consumer-DVD and set-top flavors with integrated RISC microcontroller
Sony Semiconductor, Circle No. 345 Virtuoso CXD 1930: MPEG-2 audio/video decoder based on a RISC microcontroller	MPEG-2 video decoder; AC-3and MPEG audio decoders; CSS decryption
Toshiba America Electronic Components Inc, Circle No. 346 TC81201F: MPEG-2 video decoder TC6807AF: copy-protection processor TC90A09F: video processor TC6802AF: NTSC video encoder TC6803AF: audio interface TC9425F: audio decoder	MPEG-2 video decoder; AC-3, MPEG and PCM audio decoders; CSS decryption
Zoran, Circle No. 347 Vaddis: DVD decoder based on a DSP core	MPEG-2 video decoder; AC-3 audio decoder; CSS decryption IC planned for third quarter, and the company has received a CSS license for host-based CSS decryption

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In addition to establishing an early leadership position in DVD-ROM drives, Hitachi has also begun to ship a DVD-RAM drive and believes that the technology will ultimately obsolete the floppy drive.

quently cracks, you must take responsibility for fixing the security leak. Presumably, the IC vendor will also engage in solving the problem, but it's a problem that most companies want to avoid. Therefore, you should closely evaluate security and decryption implementations.

Of the vendors in **Table 1**, SGS-Thomson and C-Cube make the strongest argument for hacker-proof decryption schemes. Both companies tightly integrate decryption and MPEG-2 functions on the same IC and never expose the decrypted data stream outside the ICs. Toshiba uses a hardwired decryption IC, but it's currently a stand-alone chip that feeds a separate MPEG-2 decoder, thus potentially exposing the decrypted data stream on circuit-board traces. Most of the other vendors use firmware to handle the decryption, and that approach requires that data is written to a local DRAM buffer. IBM goes a step further and handles decryption on the host processor, thereby placing sensitive data in system DRAM.

All the approaches certainly avoid placing decrypted data streams on an easily accessible interface, such as the PCI bus. Moreover, Chromatic, IBM, Toshiba, and ESS Technology have all taken additional proprietary-encryption precautions for all data written into memory. The companies don't say much about how their schemes work, but you as a potential customer should be able to get enough details to evaluate the schemes.

Judging audio quality

The companies selling DVD ICs also take significantly different approaches to decoding the Dolby AC-3 5.1-channel audio stream. Here again, no one but a devout audiophile likely hears the difference, but you should scrutinize the implementations for other reasons as well. IBM, for example, again turns to the Pentium host µP to handle the AC-3 audio decoding. The company claims that its AC-3 algorithm requires 20 to 25% of the MIPS available in a 200- to 233-MHz Pentium µP. Presumably, the host-based audio saves silicon costs, and the drain on the CPU is unimportant for systems playing a DVD movie.

The IBM approach would certainly have generated substantial savings in the days when DVD boards used a discrete AC-3 decoder IC that might cost $10 to $15. Today, however, several companies integrate the AC-3 function into an almost-single-chip DVD player, so some of the cost advantage has disappeared.

The approaches clearly generate theoretical quality differences. In fact, Dolby Laboratories (San Francisco), which certifies and licenses all AC-3 decoders, has developed Class A-, B-, and C-level certifications, with Class A being the highest quality. Dolby has tried not to publicize the existence of

FOR MORE INFORMATION...

For more information on the DVD products discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use *EDN*'s Express Request service. When you contact any of the following manufacturers directly, please let them know you read about their products in *EDN*.

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these classes and, in fact, would prefer not to have such levels of quality. Many industry insiders believe that Intel used its considerable influence to have the classes established so that host-based decoders could be AC-3-certified.

Host-based algorithms, such as IBM's, are limited to 16-bit sampling of the audio stream. Going to 32 bits requires too much memory and CPU overhead, and even moving to 20 bits requires a 32-bit implementation. Generally, 16-bit algorithms can achieve only Class C certification. Conversely, SGS-Thomson's hard-wired approach yields a Class A certification. Most other vendors are reluctant to reveal details of their Dolby certification because Dolby discourages such disclosure. Class A certification requires 20-bit or greater sampling, and the best quality implementations will likely use 24-bit sampling.

DVD technology will speed the convergence of computer and consumer-electronic technologies and will result in more computer systems in living rooms than ever before. Interlink Electronics' VersaPoint wireless keyboard and touchpad allow you to control a PC from your easy chair.

In a computer-centric DVD design, you must also mix the decoded video and audio streams into graphics and audio subsystems. Almost all graphics-accelerator ICs can accept video data, arbitrarily scale the size of the video, and play the video in a window or full screen. Still, no industry standard provides a way to route video to the graphics IC. In a PC environment, you have three choices for how to route the video. You could transfer it via PCI, but, because the MPEG stream is already decoded, it would likely saturate the bus. You could take the VGA output and loop it into the DVD decoder card. You could then control the video/graphics multiplexing, but you would need extra circuitry, such as video scalers, that already resides on graphics accelerators. Sigma Designs (Fremont, CA) uses this approach on its REALmagic Hollywood DVD card, but Sigma has a distinct advantage in that it specializes in video-reproduction ICs.

Most designers opt to use one of the digital-video interfaces developed by the graphics-IC companies. There's an alphabet soup of such proprietary interfaces that all sprang from the work of the VESA (Video Electronics Standards Association) and its VMC (VESA Media Channel) interface. To the DVD designer, the lack of standards means supporting multiple video interfaces and choosing which graphics accelerators a DVD design will support.

In its DVD chip set, for example, Toshiba supports ATI, S3 (Santa Clara, CA), and Cirrus Logic (Fremont, CA) interfaces. These interfaces are generally the most popular because those companies lead the graphics-IC market. SGS-Thomson has made an effort to make its VIP interface an industry standard, but the jury is still out on whether more companies will use the interface. SGS-Thomson has a potential winner with its 128-bit Riva graphics accelerator that it codeveloped with Nvidia (Sunnyvale, CA) and just began shipping. Success of that chip could help drive the VIP effort. On the other hand, the reliance on VIP in its DVD ICs could limit SGS-Thomson's market in the short term.

Integration and costs

It's clear that DVD technology has arrived, but it's equally clear that prices must drop before consumers widely adopt the technology. DVD chip sets cost $25 to $70 in the multithousand-unit quantities typical of the PC market. To sell products by the end of the year, chip-set vendors have to be at the low end of that range. Increasing the level of integration always proves to be the best way to lower prices, and single-chip implementations are arriving.

Keep a few things in mind when you evaluate the cost of DVD chip sets: The IC cost and the system cost can be quite different. For example, the SGS-Thomson Sti3560 includes a PCI interface, but other "single-chip" DVD implementations require an external PCI-bus interface. Make sure you evaluate everything required, including DACs, memory, and external microcontrollers.

Ultimately, DVD must integrate directly onto the graphics board for the technology to proliferate in the computer market. Expect some companies to have combo DVD and graphics boards this year. ATI, for example, is working on a design based on IBM's MPEG-2 decoder IC.

When you think of single-board implementations, some factors may change relative to how you evaluate the various chip sets. For example, Chromatic and its partners offer the new Mpact2 IC, which includes a hardware-based 3-D accelerator and easily handles DVD along with graphics, telephony, and audio duties. Toshiba will ship samples of the IC for $60 this month with production scheduled for October. SGS-Thomson will also have the Mpact2, and can alternatively combine its DVD chips with its Riva accelerator. You may find that companies holding multiple technologies have an advantage in providing single-board implementations.

The lowest cost implementations will likely be those that rely the most on the host CPU. IBM is clearly heading in that direction, but down the road the host will take on some or all of the MPEG-2 decoder's chores. In fact, between the end of this year and mid-1999, increases in µP performance and enhancements to graphics chips will obsolete DVD ICs in the PC market.

In the short term, even the Pentium

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II μP can't single-handedly implement a DVD player. Already, however, ATI has added features to its graphics accelerator that enable host-based DVD. Specifically, the 3D Rage Pro that just began shipping includes hardware support for motion compensation, which is the final stage of MPEG-2 decoding. With the assistance of ATI's new IC, Zoran has demonstrated its SoftDVD player running on a 233-MHz Pentium II μP. Moreover, ATI plans to support the SoftDVD technology and offer hardware-based designs.

Multipurpose devices

Some entrepreneurs will also find opportunities to integrate divergent but symbiotic technologies into one product. For example, ESS Technology targets its new ES3308 primarily at the consumer-player market but developed it in such a way that the same IC can handle set-top-box duties for digital-satellite and terrestrial-cable transmissions. You could use the IC to create a PC-based product that handles DVD and multiple set-top-box functions.

More realistically in the short term, expect a market for products similar to Gateway's (Sioux City, SD) Destination Entertainment PC. The bundled DVD technology and dual-purpose TV/monitor somewhat seamlessly merge computing and entertainment devices.

The building blocks for such products are readily available. For example, ATI's $299 All-In-Wonder card can drive a TV as well as a computer monitor. The card also includes a TV tuner, and you can use it to capture video clips from a VCR or camcorder. Interlink Electronics is shipping its VersaPoint wireless keyboard with an integrated touchpad. Simply plug an infrared receiver into mouse and keyboard ports, and you can roam the living room with your keyboard or Web-surf from your easy chair. The keyboard sells for around $100 at discount prices and for even less to OEMs.

Still, you have to address other issues in designing living-room equipment. For example, the fan in a PC actually makes a discernible noise that's bothersome while watching TV—albeit it's no problem when watching *Batman* in Surround Sound. PCs can also emit RF energy that can cause interference with standard analog audio and video signals. Despite these obstacles, it's difficult to imagine a modern living-room entertainment rack without a PC two to three years hence. EDN

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